RECOGNITION SYSTEM AND METHOD FOR USER INPUTS TO A COMPUTER SYSTEM

This is a continuation of application Ser. No. 07/889,216 filed May 27, 1992 now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates generally to recognition of user inputs to a computer system such as a pen-based computer system and, more particularly, to methods for analyzing the user inputs and providing interpretations of those user inputs.

A pen-based computer system is a small, often hand-held, computer system where the primary method for inputting data includes a "pen" or stylus. A typical pen-based computer system is housed in a small, rectangular enclosure, and has a dual-function display assembly having a viewing screen exposed along one of the planar sides of the enclosure. The dual-function display serves as both an input device and an output device. When operating as an input device, the display assembly senses the position of the tip of the stylus on the viewing screen and provides this information to the computer's central processing unit (CPU). Some display assemblies can also sense the pressure of the stylus on the screen to provide further information to the CPU. When operating as an output device, the screen displays computer-generated images developed by the CPU.

The dual-function display assemblies of pen-based computer systems permit users to operate the computer as a computerized notepad. For example, graphical images can be input into the pen-based computer by merely moving the stylus over the surface of the screen. As the CPU senses the position and movement of the stylus, it generates a corresponding image on the screen to create the illusion that the stylus is drawing the image directly upon the screen. With suitable recognition software, text and numeric information can also be entered into the pen-based computer system in a similar fashion.

What is needed is a system for recognition of user inputs to a computer system such as a pen-based system and for analysing the user inputs to determine possible meanings.

SUMMARY OF THE INVENTION

The present invention provides a system and a method for analyzing and interpreting user inputs to a computer, such as a hand-held, pen-based computer system, described herein. Inputs are received at a user interface, such as a dual function display/input screen, from users in the form of pen strokes or gestures. These pen strokes or gestures are preferably input into the CPU as an array of X and Y data points corresponding to the path of a stylus across the display/input screen. A database stores the input data points and hypotheses regarding possible interpretations of the strokes represented by the array of data points. Recognition of the input strokes and recognition of higher level combinations of strokes (forming characters and words, etc.) is performed using recognition domains, each of which performs a particular recognition task. A controller is provided for the recognition domains. An arbiter is provided for resolving conflicts among competing hypotheses

The recognition domains, or recognizers generate one or more competing interpretations for the same input. The recognizers use a data structure called a unit, where a unit is a set of subhypotheses together with all their interpretations

generated by a single recognizer. An interpretation is a description of a particular portion of the input data (strokes), where the description is based on the strokes or on other lower-level interpretations. A recognizer operates at a first level for identifying one or more groups of related subhypotheses using the unit absent any interpretations and stores the unit in the database in piece-pool memory. A recognizer has a second level of operation where each unit generated in the grouping stage is classified to provide the unit with one or more interpretations. The classified unit is stored in a unit pool memory.

One or more interpretations of the input data are combined in a hierarchical structure according to a predetermined scheme in successive steps to form higher level interpretations.

For a given hierarchy, an independent recognition domain has two required parts and one optional part. The required parts are: (1) information to establish the position of the domain in the hierarchy, and (2) knowledge about how to perform a particular recognition task; and the optional part is conditions and context constraints that the input data has to satisfy to be considered for recognition by a recognizer. The information to establish a domain as a part of a given hierarchy is information about which type of hypotheses the domain takes as input and information about which type of hypothesis the domain generates so that the type of input hypotheses for a domain uniquely establishes its position in the hierarchy. The knowledge on how to perform a particular recognition task is subdivided into two parts, where one part is the grouping knowledge for deciding which of the available strokes or hypotheses should be considered as a whole to form a new interpretation, and where the other part is classification knowledge for generating a list of interpretations from a given set of hypotheses.

A hypothesis is removed from the database when it reaches the top of the recognition hierarchy and any conflicts with another hypothesis have been resolved by the arbitration process. When a hypothesis is removed from the database, its supporting hierarchy of hypotheses, down to the constituent strokes, is removed from the database and all other hypotheses in the database that refer to the these constituent strokes, or the hypotheses that use them, are removed.

The means for extracting information from each isolated portion of the input data, the means for assigning an interpretation to each portion of the input data; the means for combining two or more interpretations of the input data to form new more integrated interpretations; the additional means for combining two or more new interpretations to form newer interpretations until a fully integrated interpretation of the input data is formed, and the means for combining two or more interpretations of the input data to form new more integrated interpretations includes a recognition hierarchy for the task of recognizing, for example, handwritten words and simple graphical shapes.

The controller, or control unit, includes means for deducing from the information provided by the recognizers, or domains, precisely which domains should be active within a specific area of the user-input screen of, for example, a pen-based system. For recognition of words, the control unit uses a character-part domain, a character domain, and a word domain within that specific area. Means are provided for pre-computing for each recognition area of a user screen what action the recognizer should take when an input of each of the expected types is seen within that area.

The system can resolve conflicts among competing